## REMARKS

### I. Status of the Claims

Claims 1 - 16 stand rejected and have been cancelled. Claims 17 - 32 have been added.

### II. Rejections Under 35 U.S.C. §112, First Paragraph

The Office Action identified a rejection to "Claim 27" as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. The Office Action then noted that "regarding claims 1 and 6, the specification and drawings as originally filed do not provide support for "three-dimensional process".

As to the content of the rejection, claim 27 was not one of the claims originally filed in the instant application. Since a typographical error evidently occurred, the applicant will assume that the rejection applies only to claims 1 and 6.

Whenever the issue of sufficiency of disclosure arises, the fundamental factual inquiry is whether a claim defines an invention that is clearly conveyed to those skilled in the art at the time the application was filed. An important implication here is that the subject matter of the claim need not be described literally (i.e. using the same terms) in order for the disclosure to satisfy the description requirement. Additionally, in order to factually support such a rejection, the Examiner has the initial burden of presenting evidence or reasons why persons skilled in the art would not recognize in an applicants disclosure a description of the invention defined by the claims.

Here, the Examiner completely omits any factual reasons for concluding that "the specification and drawings as originally filed do not provide support for "three dimensional process". In fact, processes such as stereolithography, laser scintering, fused deosition modeling and the like are known by those skilled in the art as three dimensional

fabrication processes. This is to be contrasted with conventional circuit board technologies that are widely known as 2.5 D processes.

Moreover, nowhere in the present application is the phrase "three dimensional process" recited. Rather, the language "three dimensional fabrication process" is employed. Attached is a copy of a page from a NASA report entitled "Section of Final Report: NASA ACRP NCC7-7, Bush Robots, Hans Moravec, Jesse Easudes", dated 1997, wherein on lines two and three, they note that in fabricating a three-dimensional structure, "The most convenient avenue seems to be a ten-year old prototyping method called stereolithography. Stereolithography is a three-dimensional printing process that produces a solid plastic model." Similarly, in the attached page from "The Voice - Spotlight on: ARDEC Rapid Prototyping Laboratory ...", on page 2, second paragraph, it is stated "For those who are unfamiliar with this technology, Stereolithography, is basically a three-dimensional printing process that produces a solid plastic object from data stored on a computer."

Consistent with the articles noted above, the specification identifies several "three-dimensional fabrication processes" suitable for fabricating the claimed router. The processes include, but are not limited to, stereolithography, selective laser scintering, fused deposition modeling, and laminated object manufacturing. In fact, the specification is explicit on how this is accomplished via the stereolithography process:

> "SLA comprises the preferred method of fabrication due to its known desirable resolution capabilities. Materials such as Vantico SL5510 or 5530 work well for the preferred embodiment. Generally, the 3-D additive process incrementally builds-up the signal router 20 and conductor paths 22, such as that shown in Figure 2a." (Page 5, lines 24).

Although claims 1 and 6 have been cancelled, new claims 17 and 22 correspond to claims 1 and 6, including much of the same claim language. For the reasons explained above, all of the claims are believed supported by the specification, and reconsideration is respectfully requested.

## II. Rejections Under 35 U.S.C. §112, Second Paragraph

The Office Action identified a rejection to claims 1-13 under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential structural cooperative relationships of elements, such omission amounting to a gap between the necessary structural connections.

The Applicant has cancelled original claims 1-16, and rewritten them as new claims 17 - 32 in an effort to more fully clarify the claimed subject matter.

The present invention provides a low-cost way to route hundreds of conductor paths from one surface to another. Traditionally, this was accomplished through the use of printed circuit boards (PCBs). PCBs employ two-dimensional horizontal layers for routing signals along each layer. As the layers are stacked, they are formed with vertical vias to interconnect one layer to another. The orthogonal relationship between the vias and the different layers is typically referred to by those skilled in the art as a 2.5D routing scheme.

In contrast to conventional 2.5D routing schemes, the present invention includes a router formed with a plurality of contiguous open-ended hollow paths that are routed through the router in a true free-form manner. This is accomplished through the implementation of a three-dimensional fabrication process that includes the steps "incrementally forming a portion of the router, and iterating the incrementally forming step until the router is complete." In other words, the invention enables a block or plate of material to be formed with hundreds to thousands of free-form holes or paths. Conductors (whether electrical, optical or fluid) may then be inserted into each path from end to end. In the electrical context, this allows coaxial cables to be routed in a contiguous manner through the block with no interconnections that might degrade performance.

Applicant asserts that new claims 17 - 32 provide the necessary structural cooperative relationships for patentability. Reconsideration is respectfully requested.

## III. Rejection Under 35 U.S.C. §102

The Office Action identified rejections to claims 1-16 under 35 U.S.C. 102 as being anticipated by Beaman et al (U.S. Patent No. 5,531,022).

Beaman discloses a conventional printed circuit board assembly that employs a plurality of stacked two-dimensional layers. Signal paths are routed through the layers at orthogonal orientations according to drilled and plated vertical "via" locations. Beaman's disclosure is typical for 2D and 2.5D circuit board fabrication technologies.

It is well known that anticipation under 35 U.S.C. §102 requires that each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. In re Robertson, 169 F.3d 743, 49 U.S.P.Q.2d 1949 (Fed. Cir. 1999)(*reversing Board of Patent Appeals & Interference's finding of anticipation under §102*).

**A) Claim 17**

Claim 17 recites a routing unit ... formed with a plurality of contiguous open-ended hollow paths, the open-ended hollow paths being directed in a free-form manner from the first surface through the routing unit to the second surface. The claim also recites that the routing unit and the paths are formed by a three-dimensional fabrication process (for example stereolithography) that includes an incrementally forming step and an iterating step.

A review of Beaman will show that nowhere are contiguous open-ended hollow paths disclosed that are directed in a free-form manner. Instead, Beaman discloses non-contiguous horizontal microstrip paths (along the surface of the board) that occasionally couple to a vertical via for routing to a different layer. Also, Beaman fails to disclose anything other than a conventional 2D or 2.5D fabrication process where via holes are first drilled then plated through one or more layers.

For these reasons, new claim 17 is believed patentable over the cited art, and reconsideration is respectfully requested.

**B) Claim 18**

New claim 18 recites that the incrementally forming step comprises a three-dimensional additive technique. Again, Beaman teaches only the use of conventional 2D and 2.5D circuit board lamination processes. Reconsideration is requested.

**C) Claim 19**

New claim 19 recites that the incrementally forming step comprises a three-dimensional subtractive technique. Similar to the reasons for claim 18, claim 19 is believed patentable over Beaman.

**D) Claims 20 and 21**

Claim 20 recites that the routing unit comprises a block of dielectric material, while claim 21 recites the routing unit as comprising a block of thermally conductive material.

Beaman's "router" is a circuit board, formed of a stack of substrate layers that are formed with conductive microstrip traces. Beaman's circuit board is not a "block of dielectric material", nor would it be considered as a block of thermally conductive material as those terms are commonly understood in the art. Reconsideration is requested.

**E) Claim 22**

Claim 22 recites the routing unit of claim 17 in combination with a plurality of conductors to form a hybrid conductor/board, or space transformer. This allows for routing a large number of conductors (such as coaxial cables for example) from a first spaced-apart configuration, to a second high-density configuration at low cost.

Beaman does not rout conductors in a free-form manner from one surface of his circuit board to another surface. He drills holes through one or more layers, and then plates the holes with metal to form his vertical vias. This is very different than what is claimed in claim 22. Reconsideration is respectfully requested.

**F) Claim 23**

Claim 23 recites that at least one of the plurality of conductors comprises an electrical conductor. For all of the reasons set forth with respect to claim 22, this claim is believed patentable over Beaman.

**G) Claim 24**

Claim 24 recites that at least one of the plurality of conductors comprises an

optical conductor. The Examiner alleges that Beaman discloses the use of optical conductors in Figures 15 and 22. In fact, Beaman employs an optical system (a wire bonder) to form wire (electrical) conductors in an interposer that couples to his circuit board. Optical conductors in a router as claimed in claim 24 are not disclosed, nor even remotely suggested.

**H) Claim 25**

Claim 25 recites that the conductors are fluid conductors. Beaman has nothing to do with anything but electrical circuit boards. The Examiner suggests that there is some form of obviousness rationale (in that it would be an obvious design choice to use fluid conductors or optical conductors instead of electrical conductors). The Examiner has a minimum requirement to present evidence of the motivation in doing so, but has yet to do this. Reconsideration is requested.

**I) Claims 26 and 27**

Claims 26 and 27 recite similar features to those in claims 18 and 19, and for the same reasons are believed patentable over Beaman.

**J) Claims 28 and 29**

Claims 28 and 29 depend directly and indirectly from claim 22, and for the same reasons are believed patentable over Beaman.

**K) Claim 30**

Claim 30 is directed specifically to automatic test equipment, reciting a hybrid/conductor board, a plurality of conductors routed in a free-form manner through the board, and a device-interface-board adapted to connecting to one or more devices-under-test. Beaman does not disclose or remotely suggest these claimed features.

**L) Claim 31**

Claim 31 depends from claim 30 and is believed patentable over Beaman for the same reasons as claim 30.

**M) Claim 32**

Claim 32 is directed to automatic test equipment, more specifically a semiconductor tester, that employs a testhead having pin electronics cards. The cards are interfaced to one or more devices under test via the claimed hybrid/conductor board. Beaman in no way relates to this claimed subject matter. Reconsideration is respectfully requested.

Applicants submit that all of the amendments and remarks set forth above place the claims in condition for allowance, and early notice thereof is respectfully solicited.

Respectfully Submitted

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**The VOICE** **News**

# Spotlight on: ARDEC Rapid Prototyping Laboratory - A Continuing Success Story

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**By Joe Lachowski**
**CCAC**

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Photo

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Established in December 1992, ARDEC's Rapid Prototyping Lab, part of the Close Combat Armaments Center here, continues to provide a wide variety of services to internal and external customers. Customers include the PM's , CCAC, AED, FSAC, EOD, IOC, government contractors and the U.S. Navy. To date, the Lab has provided prototypes to serve a variety of uses ranging from conceptual designs and hands-on marketing tools to functionally tested items. All are provided at a significant cost savings and in a relatively short turnaround time. When compared to Service Bureau rates and conventional prototyping techniques, an estimated savings well in excess of $500,000 has been realized to date.

Hundreds of components have been produced on the Labs SLA-250 Stereolithography Apparatus from 3D Systems. The SLA-250 has had a continuous workload, in excess of 17,000 hours of operation to date. The SLA-250 operates anywhere from 60 - 90 percent of the time during any given month (24 hour basis). Small Arms Concept Weapons, Small Arms Weapon Components, Packaging Configurations, Large Caliber Recoil Systems, Fuze Components, Mortar Components, Large/Small Caliber Projectiles, Test Fixtures and EOD Training Aids have all been produced.

The SLA-250 is the workhorse of the Lab. From the plastic epoxy resin prototypes produced, a variety of prototypes can be fabricated. These include the epoxy resin prototypes themselves, polyurethane prototypes with various material properties through silicon molding techniques and metal parts through Investment Casting utilizing "QuickCast" prototypes as patterns. Other capabilities provided by the lab include 3-D CAD design and dimensional analysis services utilizing Pro/Engineer and reverse engineering through the use of Laser Design Inc. Surveyor 2000 Laser Digitizer.

With the use of the Internet, a computer generated three dimensional model can be downloaded to the lab from anywhere in the United States. This has been done with success on a number of occasions. In some instances, a CAD file has been sent over the Internet for review and evaluation with an estimate for a prototype being provided the same day. In addition, the Internet provides ready access to the Close Combat Armaments Center at Benet Labs' SLA-250 and Watervliet Arsenals' SLA-500 to meet a customer's short timeline requirements.

In 1995 the Lab established an informal cooperative working relationship with the Rock Island Arsenal Foundry for the purpose of providing investment cast metal prototypes from "QuickCast" quickly with high quality and high success rate to our customers.

"QuickCast" is a 3D Systems proprietary prototype fabrication technique which basically fabricates a prototype on the SLA-250 which can be best be described as a hollow honeycomb pattern. The "QuickCast" pattern is used in place of the wax pattern utilized in the investment casting process. Approximately, two dozen metal castings have been provided to the ARDEC Engineering community for design evaluation purposes in the past year. Steel and Aluminum castings have all been produced.

Expanding the Stereolithography Laboratory utilization and awareness throughout the community for this coming Fall's semester, the Mechanical Engineering Technology Program at the County College of Morris will be offering an adult technical development workshop that will have the student utilize the Stereolithography SLA-250 apparatus at Picatinny Arsenal to proveout their AUTOCAD design.

For those who are unfamiliar with this technology, Stereolithography, is basically a three-dimensional printing process that produces a solid plastic object from data stored on a computer. A standard three-dimensional computer aided design software package such as ProEngineer or AutoCad is used as the input to the process. A proprietary software package then utilizes this data to create a roadmap for the stereolithography apparatus. This roadmap directs an automated laser beam to draw or print individual cross sections of the object onto a photocurable liquid plastic. The liquid plastic is solidified at the precise points where it is touched by the laser. Successive cross sections, each adhering to the cross section below it, are built one layer on top of another to form the desired object from the bottom up.

For further information, work schedule and opportunities for the rapid prototyping, contact Joe Lachowski, X2693 or Mark Leng, X5688.

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News

Section of Final Report: NASA ACRP NCC7-7, **Bush Robots**, *Hans Moravec, Jesse Easudes*

# 5: Fabrication of Structural Models

We cannot yet build an actuated mechanical model, but there are techniques that allow us to make static "sculptures" of bush robots. The most convenient avenue seems to be a ten-year-old prototyping method called stereolithography. Stereolithography is a three-dimensional printing process that produces a solid plastic model. A computer-controlled ultraviolet laser draws cross sections of the model onto the surface of photo-curable liquid plastic, hardening it. A vertical elevator system lowers the newly formed layer, while a leveling system establishes the thickness of the next layer. Successive cross sections, each of which adheres to the one below it, are built one layer on top of another to form the part from the bottom up.

We have two stereolithography machines located near us, and old, neglected one in a Carnegie-Mellon lab, and a better-maintained newer model at a local Alcoa company facility. The working volume of the first is a cube 10cm on a side, the second is a 20cm cube, both have a resolution of 0.25mm. The costs of fabricating a 10cm object can range from a few hundred to a few thousand dollars, primarily determined by the fabrication time. A large, detailed model can consume several weeks of stereolithography machine time. The process has various limitations, for instance partially fabricated objects must be self-supporting at all stages. The software controlling the machine automatically inserts struts as needed for temporary scaffolding, which must be manually removed on completion. The myriad floating fingers of an awkwardly posed, partially fabricated bush robot could require an unwieldy number of struts, so we had to plan the poses carefully. Following is a picture of the SLA-350 20cm stereolithography machine.